Course Code: MAT 482

Course Title: Complex Variables and Its Applications

Credit Weight: 3.0 Credits

Rationale of the Course:

Complex analysis is a beautiful, tightly integrated subject between different disciplines, such as applied mathematics, science, and engineering. This course provides the basic idea of the complex plane, the geometry of complex numbers, complex functions, analytic functions, and so on. The course comprises theories of complex functions of a complex variable and then makes a way to differentiation, integration, complex dynamics, power series representation, and Laurent series into territories at the edge of what is known today. The course also holds a deeper look at some applications of complex analysis, such as heat conduction, electrical engineering, fluid mechanics, etc.

Prerequisite: Knowledge of multivariable calculus (MAT250 of NSU)

Course Objectives:

1. To gain the basic concept of analytic functions of a complex variable, limit, continuity, and differentiability of complex functions.
2. To learn key applications of the Cauchy Residue Theorem, in particular its use in calculating improper integrals.
3. To understand the ideas of the Taylor series, Laurent series, and the singularities.
4. To learn how to apply conformal mapping and bilinear transformation to problems in applied mathematics, fluid dynamics, and electrodynamics.

Course Learning Outcomes (CLOs)/Course Outcomes (COs):

At the successful completion of this course, the student will have demonstrated the ability to:

(CLO1) Understand the basic properties and algebraic operations of a complex number, the notion of continuity and differentiability of a function of a complex variable, and the necessary and sufficient conditions of differentiability by means of the Cauchy-Riemann equations.

(CLO2) Compute integrals of a function of a complex variable on a contour with the aiding of Cauchy's integral formula.

(CLO3) Find a Taylor or Laurent series expansion of a function of a complex variable and learn how to determine the region of convergence of such a series.

(CLO4) Find residues of a function of a complex variable at singularities and compute improper integrals of real-valued functions by means of the Residue Theorem.

(CLO5) Implement conformal mapping and harmonic functions to solve certain problems in applied mathematics, fluid dynamics, electrodynamics, etc.

Course Contents:

The course includes the following topics:

- **Introduction to complex variables:** Complex numbers, Fundamental operations of a complex number, Euler's formula, de Moiver's formula
- **Functions of a complex variable**: Mappings, Limits, continuity of a complex function
- **Differentiability of a complex function**: Cauchy-Riemann equations, analytic functions, harmonic functions, complex potentials
- **Definite integral of complex functions**: Definite integral in the complex plane, Contours, line integral of complex functions along a contour. Cauchy-Goursat Theorem and Cauchy's integral formula
- **Infinite series :** Infinite series, the convergence of series, Taylor series, Laurent Series of analytic functions
- Singular points, Residues & Cauchy's residue theorem. Application of Residues: evaluation of improper integrals, Jordan Lemma, Meromorphic function.
- **Conformal Mapping:** Mapping by elementary functions. Conformal mapping and Bilinear Transformations. Applications of Conformal Mapping: Temperature of a thin plate. Applications of Conformal Mapping:Two-dimensional fluid flow or related applications.
- The Schwarz-Christoffel Transformation and its applications to real-life problems.

Reference Books:

(1) Schaum's Outline of Theory and Problems of Complex Variables by Murray R. Spiegel.

(2) Complex Analysis for Mathematics and Engineering by J. Mathews, R. Howell A. C.

(3) A First Course in Complex Analysis with Applications, Dennis G. Zill

Mapping of Course Outcomes

CLOs	Course Outcomes (CO)	Bloom's taxonomy domain/level *(C: Cognitive P: Psychomotor A: Affective)*	Delivery methods and activities	Assessment tools
CLO1	Understand the basic properties and algebraic operations of a complex number, the notion of continuity and differentiability of a function of a complex variable, and the necessary and sufficient conditions of differentiability by means of the Cauchy-Riemann equations.	**C1, C2, C3**	Lectures, Notes	Quiz, Assignment, Discussions
CLO2	Compute integrals of a function of a complex variable on a contour with the aiding of Cauchy's integral formula.	**C3, C4**	Lecture, group discussion	Assignment, Class participation, Midterms
CLO3	Find a Taylor or Laurent series expansion of a function of a complex variable and learn how to determine the region of convergence of such a series.	**C1, C3, P2**	Lecture, group discussion	Assignment, Class participation, Midterms
CLO4	Find residues of a function of a complex variable at singularities and compute improper integrals of real-valued functions by means of the Residue Theorem.	**C1, C3, P2**	Lecture, group discussion	Assignment, Class Participation, Final Exam
CLO5	Implement conformal mapping and harmonic functions to solve certain problems in applied mathematics, fluid dynamics, electrodynamics, etc.	**C4, P2**	Lecture, group discussion	Assignment, Class Participation, Final Exam

Mapping Course Learning Outcomes (CLOs) with the PLOs

Table 1 Relationship between PLOs and PEOs

PLOs / CLOs	PLO(a): Mathematical Knowledge	PLO(b): Problem Analysis	PLO(c): Development/Design Solutions	PLO(d): Investigation and Make a Decision	PLO(e): Usage of Modern Tools of Computation	PLO(f): Professionalism and sustainability	PLO(g): Ethics	PLO(h): Individual work and teamwork	PLO(i): Communication	PLO(j): Life-long Learning
CLO1	S	S	M							
CLO2	S	S	S	S	M					
CLO3	S	M	M	S				L	L	L
CLO4	M	M	L	S			M	M	L	L
CLO5			S		S		L	S	L	M

Note: S: Strong correlation, M: Medium correlation, L: Low correlation

Mapping Course Learning Outcomes (CLOs) with the Teaching-Learning & Assessment Strategy

	Teaching Strategies						Assessment Strategies						
CLOs	Class Lecture	In-class Q/A	Group discussions	Assignments/Ho	In-class problem solution	Computer Lab works	Continuous Assessments	Quizzes	Written exams (Midterm/Final)	Home	Oral Viva	Presentations	Lab Report
CLO1	√	√		√			√	√	√				
CLO2	√		√	√	√			√	√	√			
CLO3	√	√	√	√			√	√	√		√		
CLO4	√	√	√		√		√	√	√	√		√	
CLO5	√	√		√					√	√		√	

Course Assessment Policy:

Course Assessment System:	Attendance	10%
	Assignments (Minimum 4)	10%
	Quizzes (Best 3 of 5)	20%
	Mid-Term	20%
	Final Exam	40%
Grading Policy:	As per the NSU grading system.	
Attendance Policy:	As per NSU policy.	

Exams & Make-up Exam Policy

NO makeup for quizzes and NO Formative assessment will be retaken under any circumstances. If a student misses the Midterm and/or Final exams due to circumstances beyond their control (official valid documents are required) and is informed beforehand (if possible), a reasonable arrangement may be considered. Please note that the retake exam questions are generally a bit tricky and critical compared to the regular exam questions. **Students may get the opportunity to see/recheck their midterm and Final exam scripts. Cell phones are prohibited in exam sessions**.